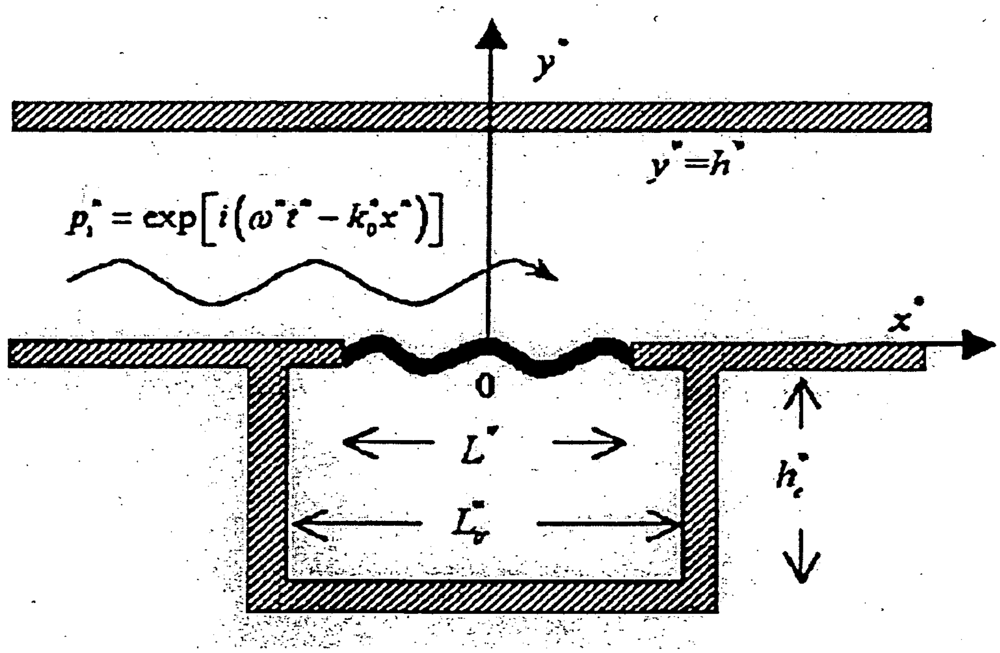


Figure 1

Given h

D

Determine hc, L from the practical considerations
Use the minimum m for the membrane

C

Vary T from 0 to $\rho_0 {c_0}^2 h^2$

B

Vary ω, $\omega=2\pi f$, $f=0$ to $c_o/2h$

Find the fluid loading p_{+rad}, p_{-rad}, p_{-ref} as well as the modal impedance Z_{jl} for a unit vibration velocity which are given below, by Eqs. (13), (14), (16) and (17).

$$p_{+rad} = \frac{L}{2}\sum_{n=0}^{\infty} c_n \psi_n(y) \int_0^1 \psi_n(y')V(x') \times \left[H(x-x')e^{-ik_n(x-x')} + H(x'-x)e^{+ik_n(x-x')} \right] d\xi'.$$

$$p_{-rad} = \frac{L_c}{2}\sum_{n=0}^{\infty} c_{nc} \psi_n(y_c) \int_0^1 \psi_n(y_c')[-V(x_c')] \times \left[H(x_c-x_c')e^{-ik_{nc}(x_c-x_c')} + H(x_c'-x_c)e^{+ik_{nc}(x_c-x_c')} \right] d\xi'.$$

$$p_{-ref} = \frac{L_c}{2}\sum_{n=0}^{\infty} c_{nc} \psi_n(y_c) \int_0^1 \psi_n(y_c')[-V(x_c')] \frac{2}{e^{ik_{nc}(2L_v)}-1} \times \left[\cos k_{nc}(x_c-x_c') + e^{ik_{nc}L_v} \cos k_{nc}(x_c+x_c') \right] d\xi'.$$

$$Z_{jl} = \int_0^1 2\sin(l\pi\xi)(p_{+rad} - p_{-rad} - p_{-ref})_j^1 d\xi,$$

where unit amplitude $V(x') = \sin(j\pi\xi')$.

A

Figure 2a

A

Solve the dynamics Eq.(22) as part of the Galerkin procedure

$$\begin{bmatrix} Z_{11}+L_1 & Z_{12} & \cdots & Z_{1N} \\ Z_{21} & Z_{22}+L_2 & \cdots & Z_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ Z_{N1} & Z_{N2} & \cdots & Z_{NN}+L_N \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_N \end{bmatrix} = - \begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_N \end{bmatrix}.$$

where $L_j = mi\omega + \frac{T}{i\omega}\left(\frac{j\pi}{L}\right)^2$,

$I_j = \int_0^1 p_i \sin(j\pi\xi)d\xi$ and $p_i = e^{-ik_0x}$, to obtain $V_j, j = 1,2,3,\ldots$

Find the reflection wave from V_j according to Eqs. (27) and (28), shown below,

$$p_r = \frac{p_{+rad}\big|_{n=0,x\to-\infty}}{e^{ik_0x}} = \frac{1}{2}\int_{-L/2}^{+L/2} V(x')e^{-ik_0x'}dx'$$

$$= \frac{1}{2}\sum_{j=1}^{\infty} V_j \int_{-L/2}^{L/2} \sin(j\pi\xi')e^{-ik_0x'}dx'.$$

and the transmitted wave from Eq. (24),

$$p_t = p_{+rad}\big|_{n=0,x\to+\infty} + p_i = \frac{1}{2}\int_{-L/2}^{+L/2} V(x')e^{ik_0x'}dx' + 1$$

$$= \frac{1}{2}\sum_{j=1}^{\infty} V_j \int_{-L/2}^{L/2} \sin(j\pi\xi')e^{ik_0x'}dx' + 1.$$

Hence the transmission loss from Eq. (25) is calculated as $\mathrm{TL} = -20\log_{10}|p_t|$.

A2

Figure 2b

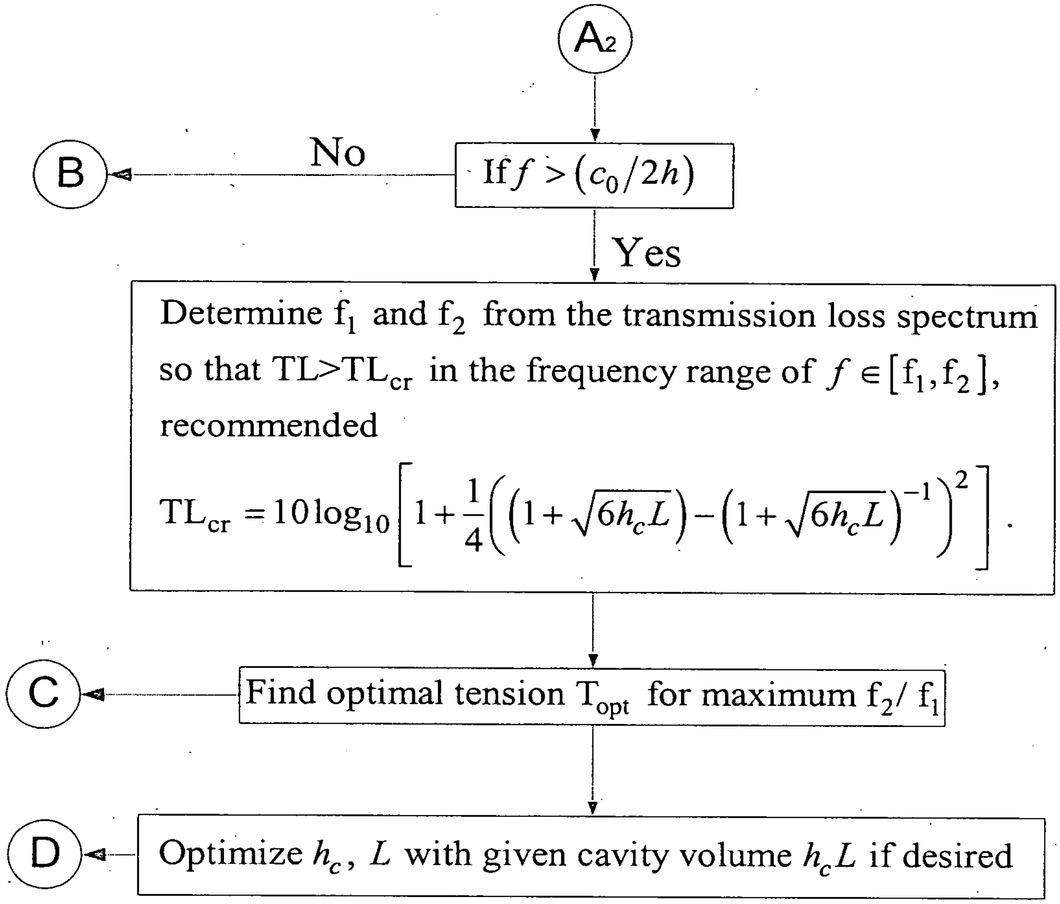

A2
If $f > (c_0/2h)$
No
B
Yes
Determine f_1 and f_2 from the transmission loss spectrum so that TL>TL_{cr} in the frequency range of $f \in [f_1, f_2]$, recommended
$TL_{cr} = 10\log_{10}\left[1+\frac{1}{4}\left(\left(1+\sqrt{6h_cL}\right)-\left(1+\sqrt{6h_cL}\right)^{-1}\right)^2\right]$.
Find optimal tension T_{opt} for maximum f_2/f_1
C
Optimize h_c, L with given cavity volume h_cL if desired
D

Figure 2c

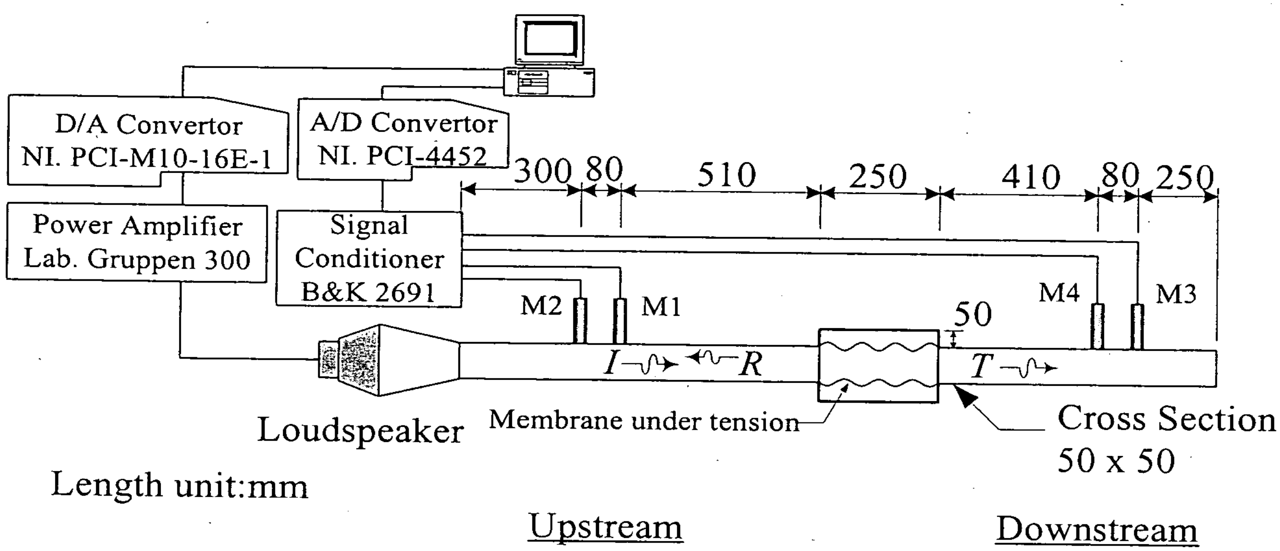

D/A Convertor
NI. PCI-M10-16E-1
A/D Convertor
NI. PCI-4452
Power Amplifier
Lab. Gruppen 300
Signal
Conditioner
B&K 2691
300
80
510
250
410
80
250
M2
M1
M4
M3
50
I
R
T
Loudspeaker
Membrane under tension
Cross Section
50 x 50
Length unit:mm
Upstream
Downstream

Figure 3

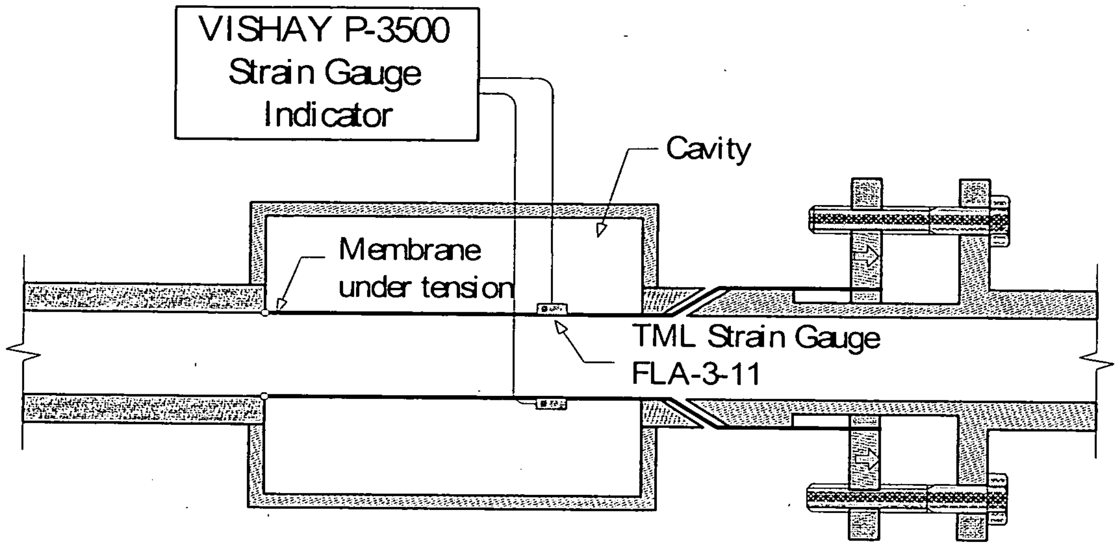

VISHAY P-3500
Strain Gauge
Indicator
Cavity
Membrane
under tension
TML Strain Gauge
FLA-3-11

Figure 4

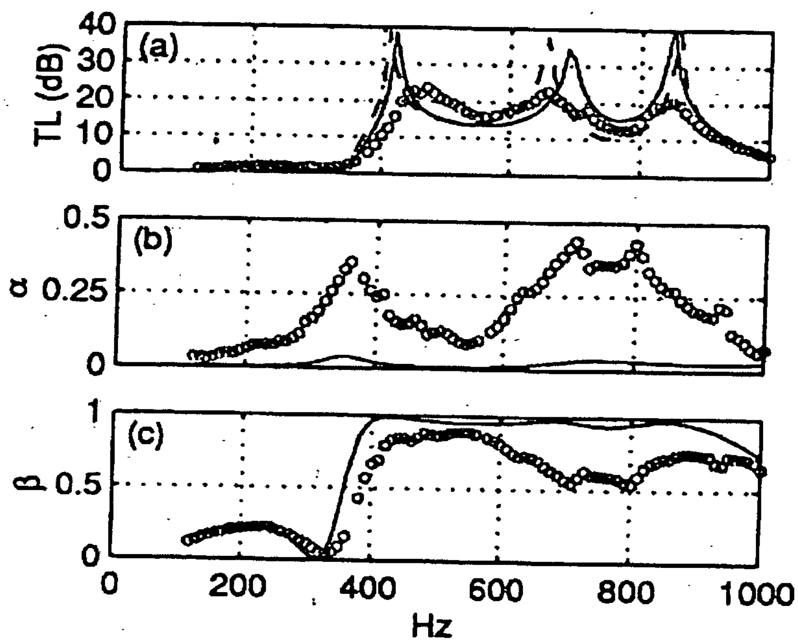
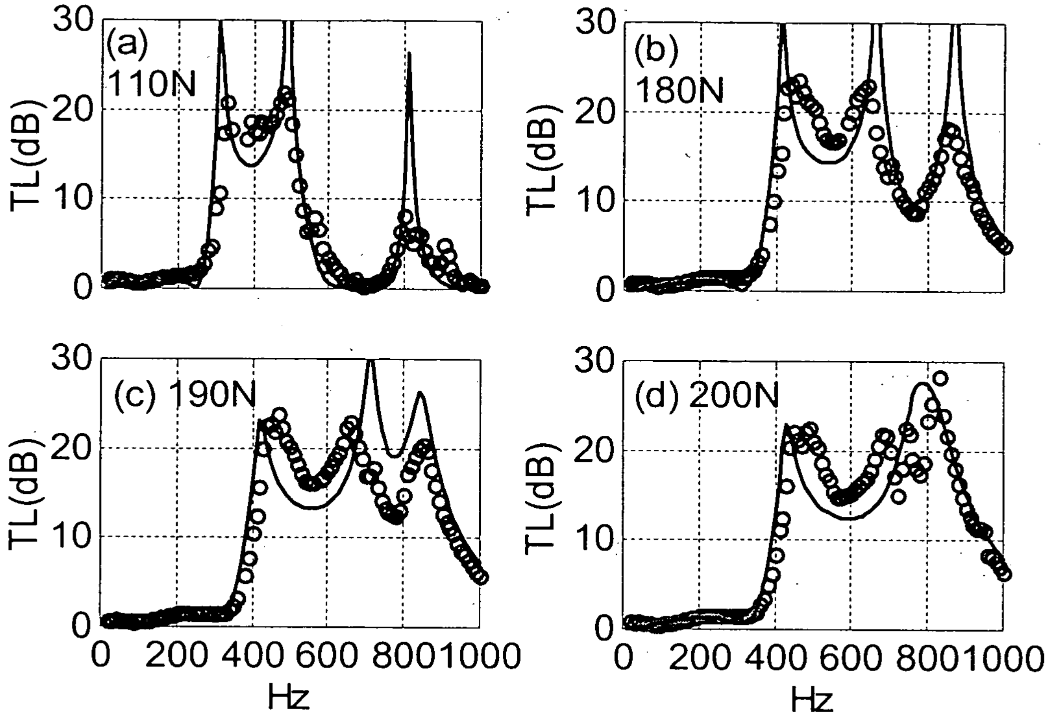


Figure 5



30
20
10
0
TL(dB)
(a)
110N
(b)
180N
(c) 190N
(d) 200N
0
200
400
600
800
1000
Hz

Figure 6

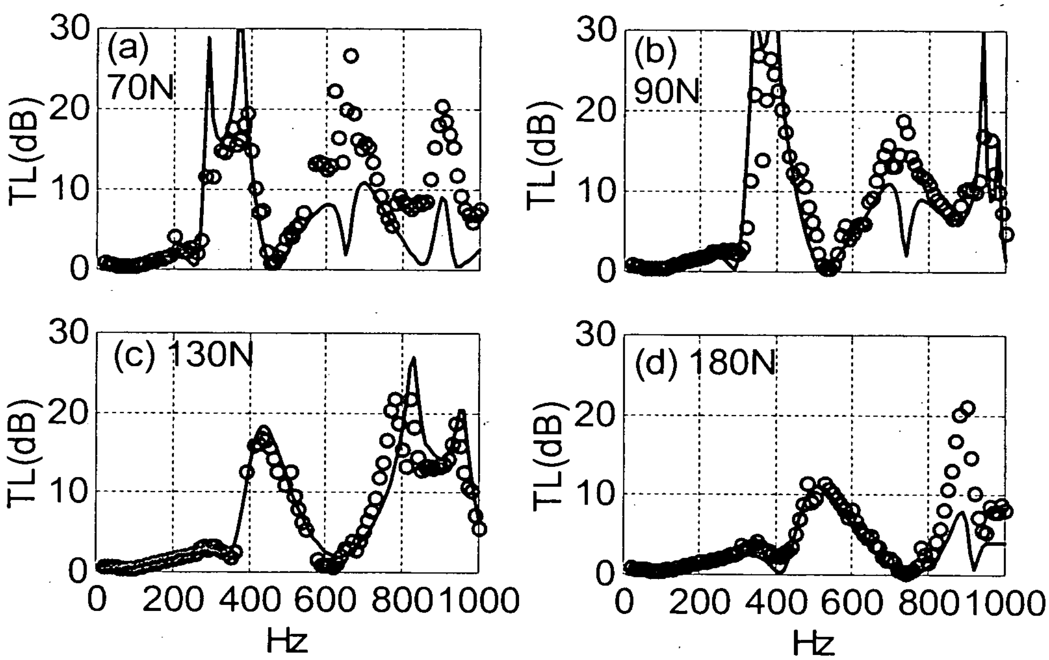


Figure 7

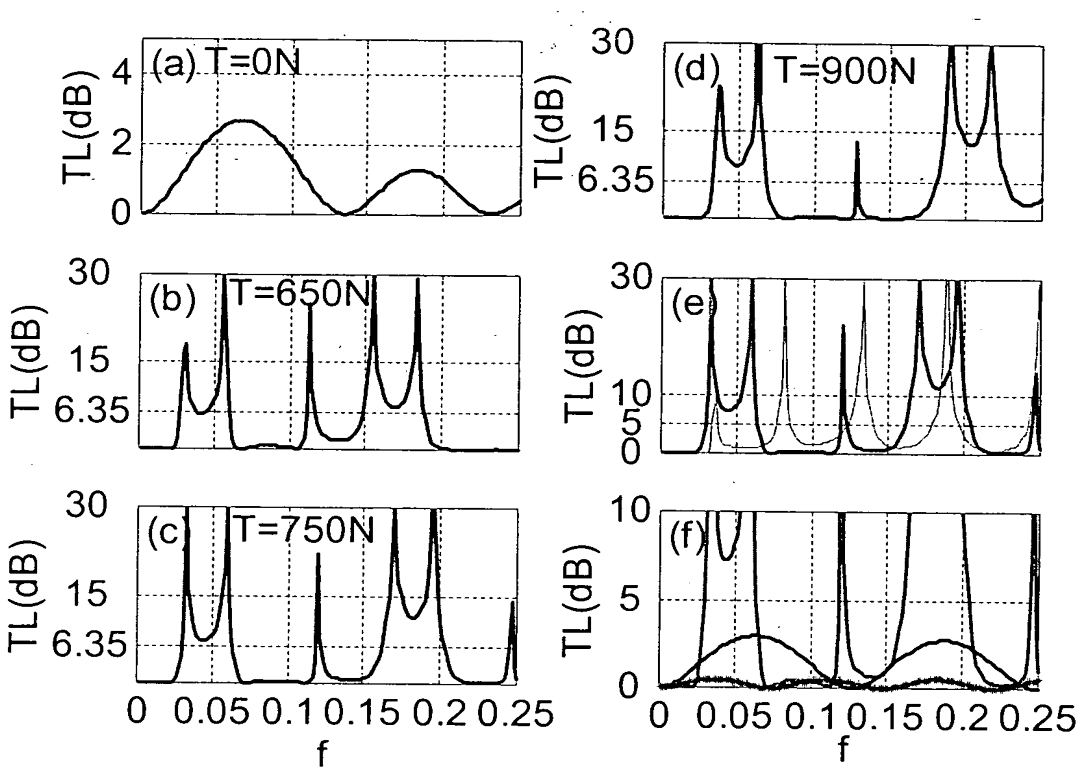
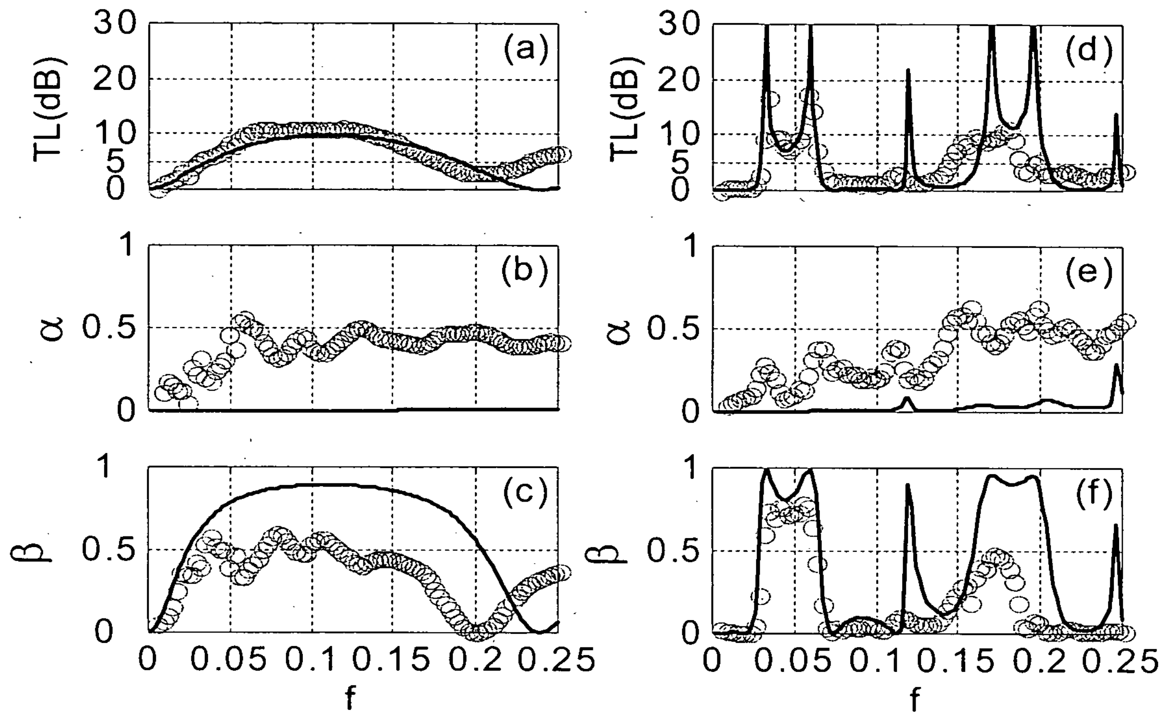


Figure 8



30
20
10
5
0
TL(dB)
(a)
1
0.5
0
α
(b)
1
0.5
0
β
(c)
0
0.05
0.1
0.15
0.2
0.25
f
30
20
10
5
0
TL(dB)
(d)
1
0.5
0
α
(e)
1
0.5
0
β
(f)
0
0.05
0.1
0.15
0.2
0.25
f

Figure 9